The EarthCARE simulator applied to I3RC benchmarks

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The EarthCARE simulator is being developed as part of the preparatory work for the Japanese/ European Earth Clouds and Aerosol Explorer (EarthCARE) mission. The mission is expected to fly in the 2011/2012 time frame and will combine, on a single platform 1) A cloud Radar 2) A High Spectral resolution Lidar 3) A Cloud multispectral imager 4) Three-view long- and short-wave Broad-Band Radiometers.

^ The Ecare simulator has initailly been developed under contract from ESA by a number of institutions lead by KNMI. The EarthCARE simulator is available via FTP at bbc.knmi.nl user:simguest; password:S139st

1. *Aim and Description*

The EarthCARE simulator is being developed to support Engineering studies as well as retrieval algorithm development. The focus is on the high fidelity simulation of the responses of active and passive sensors taking into account 3-D structures of clouds and multiple scattering. The main forward model components of the simulator are 1) a Cloud Radar Simulator 2) a 3-D Monte Carlo Semi-analytical Lidar Multiple scattering code 3) a 3-D Short Wave Monte-Carlo code 4) a 3-D Long-Wave Inverse Monte-Carlo code (see Figure 1).
All components have been designed to work together in a physically consistent manner avoiding any instrument specific parameterisations. The scattering properties of a 3-D scene are obtained using explicit size distribution information in combination with information contained in a separate scattering property database. This leads to a consistent structure regardless of the number of wavelengths involved.

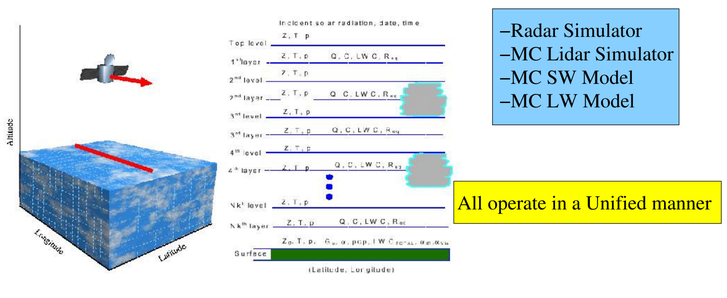

***Figure 1**. Illustration of the simulation concept*

2. *I3RC Phase-II cases*

2.1 *I3RC stcu example*

The simulator codes have been applied on a preliminary basis to a number of the I3RC benchmarks. An example of the outputs of the short and long-wave MC codes is shown in Figure 2. It can be seen that there is a good qualitative correspondence between the nadir reflectivity, the 100 micron brightness temperature (BT) and the cloud optical thickness (OT). The positive correspondence between OT and BT (i.e. higher temperature corresponds to higher OT) is a result of temperature increase with height above ground for the first 500m or so (inversion). Note that the simulations are not monochromatic and that the I3RC phase function was not directly used which may lead to differences in the effective phase function at critical angles (this may explain the large differences when looking into the backscatter direction).

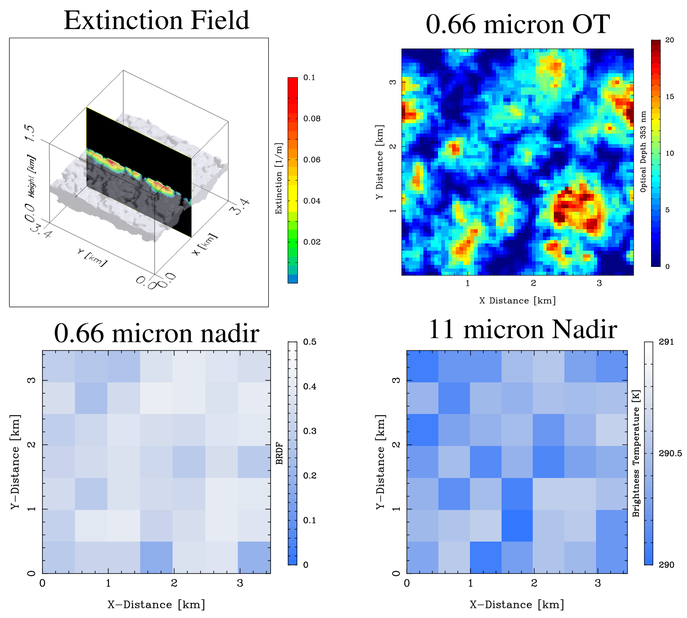

***Figure 2**. Shortwave and longwave fluxes as seen by a 500m resolution cloud-multi spectral imager (resolution of the ECARE imager)*

2.3 *Retrieval simulations*

Lidar and radar module results applied to the same stcu scene are shown in Figure 3. For the lidar, the shots are spaced every 100m. In the radar case the minimum sensitivity is about -35 dBz, the pulse width is ~500m and the return is oversampled at 100m. The blurring of the cloud return and the contamination due to the surface return are bot clearly seen.

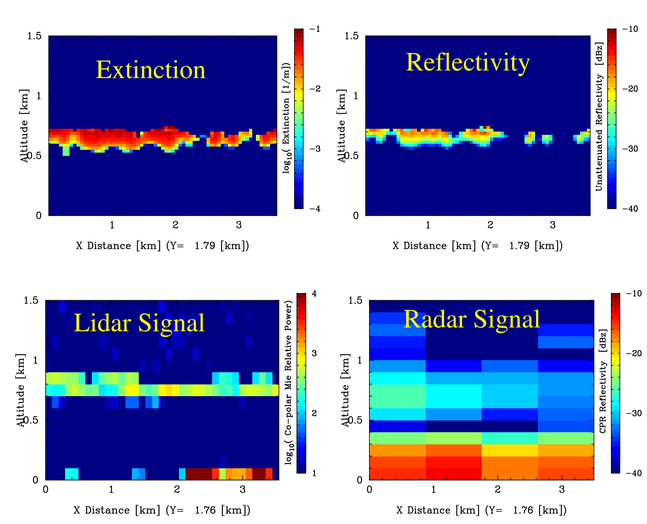

***Figure 3**. Upper panels show idealised extinction (at 353 nm) and radar reflectivity. Bottom panels show what the instruments would measure taking into account the appropriate instrument characteristics*

2. *I3RC Phase II Experiments: comparisons with other models*

STCU Exp. 7: SZA=60 l=660nm SurfAbs=0.420 ==> Irad=0.7425

THETA	PHI	ECARE	DZLR1	DZLR2	UCOL1	UCSB	UNIK
180	00	0.369±0.001	0.360	0.360	0.367	0.425	0.535
120	00	0.840±0.002	0.635	0.630	0.645	0.345	0.645
120	90	0.464±0.001	0.475	0.475	0.485	0.345	0.635
120	180	0.898±0.003	0.820	0.820	0.860	0.350	0.910

Case	Exp.	SZA	l	ECARE	DZLR1	DZLR2	UCOL1	UNIK
STCU	11	0	0.66	0.437±0.005	0.440	0.430	0.46	0.515
	12	60	0.66	0.289±0.003	0.351	0.351	0.360	0.535
	13	0	2.1	0.268±0.002	0.330	0.330	0.350	0.440
	14	60	2.1	0.300±0.001	0.220	0.220	0.220	0.430
CU	11	0	0.66	0.317±0.006	0.330	0.330	0.335	0.165
	12	60	0.66	0.220±0.0005	0.225	0.230	0.230	0.269
	13	0	2.1	0.320±0.0002	0.300	0.300	0.305	0.110
	14	60	2.1	0.1513±0.0002	0.140	0.142	0.143	0.205

3. *Conclusion*

The EarthCARE simulator is also being adapted to be applicable to CLOUDSAT and CALYPSIO. For both EarthCARE and the A-train the simulator will be a useful tool for conducting studies aimed at how best to combine the 2-D (but broad swath views) from the passive sensors with the detailed vertical (but limited swath) information provided by lidar and radar.
Just recently, the I3RC community model was installed and used with Phase II Exp. 6. The implementation of the domain using several components is not yet completely successful. The transmittance for SZA=60° at l=660nm was 3% higher than determined with the ECARE simulator. We plan to add the radiance simulation method of Barker et al. (JAS, 2003) to the I3RC community model in the near future.

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